NATIONAL BUREAU OF STANDARDS REPORT

6922

PERFORMANCE TESTS OF AN AUTOMATIC
RENEWABLE MEDIA AIR FILTER
ROLL-KLEEN, MODEL 3-70

manufactured by
Farr Company, Los Angeles, California

by

Carl W. Coblentz and Paul R. Achenbach

Report to
Public Buildings Service
General Services Administration
Washington 25, D. C.

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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Carl W. Coblentz and Paul R. Achenbach
Air Conditioning, Heating, and Refrigeration Section
Building Technology Division

to

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IMPORTANT NOTICE

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1. Introduction

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of an automatic renewable media air filter were determined. The scope of this examination included the determination of the arrestances of the particulate matter in the laboratory air and Cottrell precipitate, at the rated air flow rate of the device, and at air flow rates 20 percent above and below this rate; it included, further, the observation of the pressure drop, the automatic advancement of the filter medium, and the determination of the dust-holding capacity of the filter medium.

2. Description of Test Specimen

The test specimen was manufactured and supplied for test purposes by the Farr Company of Los Angeles, California. It was identified as their Roll-Kleen Model 3-70. The filter medium reported on was the fourth such roll supplied by the manufacturer since the performance of the earlier mats did not meet applicable Government applications with regard to either arrestance or dust-holding capacity.

The filter medium was a glass fiber mat about 1 1/2" thick and reinforced on the downstream side by a rigid webbing. The glass fibers appeared to be bonded by an organic fibrous material and were covered with an adhesive. The mat was supplied in a 3-ft wide roll, compressed to approximately 1/2 in. thickness. The clean roll was suspended in the upper part of the housing and, after passing the 24 in. square air flow opening, was rolled up on another spool at the bottom of the housing by an electric motor. While passing from the clean roll at the top of the housing to the bottom roll, the medium was backed up by a stationary grid that prevented excessive deflection of the filter mat as it passed across the air flow opening. The electric motor was controlled by a

pressure switch, General Controls Type L-48A. This pressure switch started the motor, i.e., the advance mechanism, when a certain pressure drop across the filter medium was reached. This pressure drop could be selected in a wide range, whereas, the differential of about 0.07 in. W.G was fixed.

3. Test Method and Procedure

The arrestance measurements were made in accordance with the NBS "Dust Spot Method" described in a paper by R. S. Dill and entitled, "A Test Method for Air Filters" (ASHVE Transactions, Vol. 44, p. 379, 1938).

For test purposes, the housing with the filter media in place was installed in the test apparatus and carefully sealed to prevent inward leakage of air except through the measuring orifice. The desired rate of air flow through the filter was established and samples of air were drawn from the center points of the test duct two feet upstream and eight feet downstream of the test specimen at equal rates and passed through known areas of Whatman No. 41 filter paper. The change of the opacity of these areas was determined with a sensitive photometer which measured the light transmission of the same spot on each sampling paper before and after the test. The two sampling papers used for each test were selected to have the same light transmission readings when clean.

For determining the arrestance of the filter, with Cottrell precipitate as the test dust, different size areas of sampling papers were used upstream and downstream of the filter in order to obtain a similar increase of opacity on both sampling papers. The arrestance A (in percent), was then calculated by the formula:

$$A = \left(1 - \frac{S_D}{S_U} \times \frac{\Delta D}{\Delta U}\right) \times 100$$

where S_U and S_D were the upstream and downstream sampling areas and ΔU and ΔD the observed changes in the opacity of the upstream and downstream sampling papers, respectively.

For determining the arrestance of the particulate matter in the laboratory air, equal sampling areas were used for the upstream and downstream samplers. A similar increase of the opacity of the upstream and downstream filter papers was

obtained by passing the sampling air through the upstream paper only part of the time while operating the downstream sampler continuously. This was accomplished by installing one solenoid valve in the upstream sampling line and another one in a by-pass line. The valves were operated by an electric timer and a relay so that one was open while the other one was closed during any desired percentage of the 5-minute timer cycle, reversing the position of the two valves during the remainder of the cycle. The arrestance, A (in percent), was then determined with the following formula:

$$A = 100 - T \times \frac{\Delta D}{\Delta U}$$

where T is the percentage of time during which air was drawn through the upstream sampler, ΔU and ΔD being the changes of opacity of the sampling papers, as previously indicated.

The pressure drop of an automatic self-cleaning air filter of this type increases during operation due to the accumulating dust load until it reaches the value at which the pressure switch is set to operate the advance mechanism. When the clean media is moved into the air stream, the pressure drop decreases until the pressure switch stops the advance mechanism. The filter then operates repetitively in the on-off range of the pressure switch, the pressure differential controlling the length of the clean blanket that is moved into the air stream and the rate of dust accumulation determining the frequency of the cycles. The operation of this type of filter at a higher average pressure drop will increase the dust load per unit area of the filter medium. This saving on filter material, however, tends to be offset by the increase of the required blower power. The maximum pressure drop of slightly below 0.5 in. W.G. selected for this test corresponds to common operating practice for this type of filter.

The following procedure was used for determining the performance of the test specimen. After the filter assembly, with the new mat in place, had been installed in the test apparatus, the pressure drop of the clean blanket was determined at the rated face velocity of 500 ft/min, i.e., at an air flow rate of 2000 cfm, and also at velocities of 20 percent above and below this value. To determine the uniformity of the filter mat, the blanket was then advanced approximately 4 feet and the above pressure drop measurements were repeated. Thereafter, several determinations of the arrestance were made

with the particulate matter in the laboratory air as the aerosol, followed by arrestance determinations with Cottrell precipitate.

At the request of the manufacturer's representative, who attended the test, some of these arrestance measurements were made with Diglass filters instead of Whatman paper. No significant difference in the arrestance value could be established, using these two papers for collecting the sample. It had been assumed that the differences in performance of previous filter mats observed at this Bureau and at the manufacturer's plant were the result of using different sampling paper.

After these arrestance determinations were made, the loading of the filter with a mixture of 96 parts by weight of Cottrell precipitate and 4 parts of lint was started. The Cottrell precipitate had been sifted previously through a 100-mesh screen and was dispersed into the test apparatus in a ratio of 1 gram per 1000 cu ft of air. The lint was introduced into the air stream separately and had been prepared by grinding No. 7 cotton linters through a Wiley mill with a 4 millimeter screen.

After the blanket had advanced several steps, the arrestance determinations with both aerosols were repeated. The distance of each advance of the filter media was observed by means of small markers fastened to the mat. These markers moved alongside a yardstick mounted in the filter housing and could be observed through a glass window in the test duct. A pilot light was installed parallel with the advance motor and enabled the operator to record the pressure drop of the filter mat. Altogether, a total of 20 advance cycles was observed during which the blanket moved 49 inches. At the termination of the test, a group of arrestance determinations with Cottrell precipitate were conducted at face velocities 20 percent above and below the rated air flow of the specimen. A total of 21 arrestance determinations were made during the test.

4. Test Results

The test results are summarized in Tables 1 and 2. Table 1 shows the observed values for dust load and the average arrestance values at certain positions of the filter mat using the particulate matter in the laboratory air or Cottrell precipitate, at the rated air flow and at values 20 percent above and below the rated flow.

Table 1

Summary of Arrestance Determinations
Roll-Kleen Model 3-70

Dust Load g/ft width	Air Flow Rate cfm	Advance of Mat in.	Arrestance %	Aerosol *
0	2000	0	16	A
15	2000	0	70	C
312	2000	16	79	C
570	2000	32	81	C
730	2000	46 1/2	82	C
736	2000	46 1/2	20	A
748	1600	46 1/2	85	C
760	2400	46 1/2	80	C

* Aerosol A - Particulate matter in the laboratory air.
Aerosol C - Cottrell precipitate in the laboratory air.

NOTE: Each arrestance value presents the average of two or more individual arrestance determinations.

The dust load is reported in grams per foot width, referring to the 2-ft square air flow opening. At the end of the test, a total of 1532 grams of dust and lint had been introduced into the test apparatus, and no fallout was determined in the upstream portion of the duct so that the full amount had reached the filter.

The arrestance of the particulate matter in the laboratory air with a clean filter medium was observed to average 16 percent based on 3 tests. The arrestance of Cottrell precipitate for the clean filter was 70 percent, which is the average of 4 individual arrestance determinations which ranged from 69.2 to 71.9%.

It will be noted that the arrestance of Cottrell precipitate was 79% when the filter mat had moved 16 in. but varied between 81 and 82% after a 32-in. movement of the filter medium at rated face velocity. Steady state arrestance of Cottrell precipitate was approximately 81%, and of the particulate matter in the laboratory air, about 20%, at the rated flow. The arrestance of Cottrell precipitate increased to 85% when the air flow rate was reduced by 20%, and decreased to 80% when the air flow rate was increased by 20%.

The dust load, and pressure drop before and after each advance of the filter medium, together with the incremental and total mat travel are shown in Table 2 for the entire test period.

Table 2

Mat Travel, Dust Load and Pressure Drop
Roll-Kleen Model 3-70
at Rated Face Velocity of 500 ft/min

Dust Load	Travel of Mat, in.		Pressure Drop, In. W.G.	
g/ft width	Advance	Total	Before Advance	After Advance
0	-	-	0.170	-
213	5	5	0.495	0.420
240	3	8	0.460	0.400
271	2	10	0.460	0.400
302	3	13	0.495	0.420
334	3	16	0.495	0.415
365	2	18	0.485	0.410
386	2	20	0.500	0.440
417	2 1/2	22 1/2	0.500	0.420
448	2	24 1/2	0.495	0.420
469	2 1/2	27	0.495	0.420
490	2 1/2	29 1/2	0.490	0.415
521	2 1/2	32	0.495	0.420
531	2	34	0.495	0.420
562	2	36	0.495	0.430
593	2	38	0.500	0.430
614	2	40	0.495	0.425
645	2 1/2	42 1/2	0.495	0.420
674	2	44 1/2	0.485	0.425
696	2	46 1/2	0.490	0.425
729	2 1/2	49	0.495	0.420

The pressure drop of two sections of the clean filter mat, 4 feet apart on the roll is shown in Table 3. It indicates a variation of about 5% in the pressure drop for two sections of the blanket 4 feet apart.

Table 3

Uniformity of Filter Medium
Roll-Kleen Model 3-70

Air Flow Rate cfm	Face Velocity ft/min	Pressure Drop, In. W.G. 1. Section	4 ft Further
2400	600	0.218	0.230
2000	500	0.160	0.170
1600	400	0.115	0.120

The dust load values shown in Tables 1 and 3 are the cumulative weights of Cottrell precipitate and lint that had been introduced into the test apparatus at the beginning of each advance of the filter medium. With the exception of the first advance cycle, the blanket advanced between 2 and 3 in. for each step. The individual advance could not be observed much closer than ± 1/2 in. and it can be assumed, therefore, that the advance distance was practically the same for each step after the first 16 inches of mat travel. The average pressure drop before the advance was 0.491 in. W.G., with a maximum value of 0.500 and a minimum of 0.460 in. W.G., whereas, the pressure drop at the termination of the advance cycle averaged 0.420 in. W.G., with a maximum value of 0.440 and a minimum of 0.400 in. W.G.

The amount of Cottrell precipitate collected on a unit area of filter medium during the steady state operation of the test specimen provides a measure of the consumption of mat length during actual use. Disregarding the insignificant mass of particulate matter collected on the filter during the arrestance determinations with laboratory air, the dust-holding capacity per unit area at rated air flow is expressed by the slope of the straight line in Fig. 1. This line was drawn to approximate the least mean square distances of the points of observation. According to this line, there were 750 - 250 = 500 grams per foot width of dust received by the filter mat while the filter mat traveled from the 8.7- to the 51.5-inch position, a distance of 42.8 inches, or 3.57 ft. Therefore, the dust-holding capacity was $\frac{500}{3.57} = 140$ grams per square foot. Table 4 below presents a summary of the performance data for this filter.

Table 4

Summary of Test Results

Pressure Drop, clean
    at 600 ft/min Face Velocity - 0.230 in. W.G.
    at 500 ft/min Face Velocity - 0.170 in. W.G.
    at 400 ft/min Face Velocity - 0.120 in. W.G.

Average Operating Pressure* - 0.491 in. W.G. to 0.420 in. W.G.

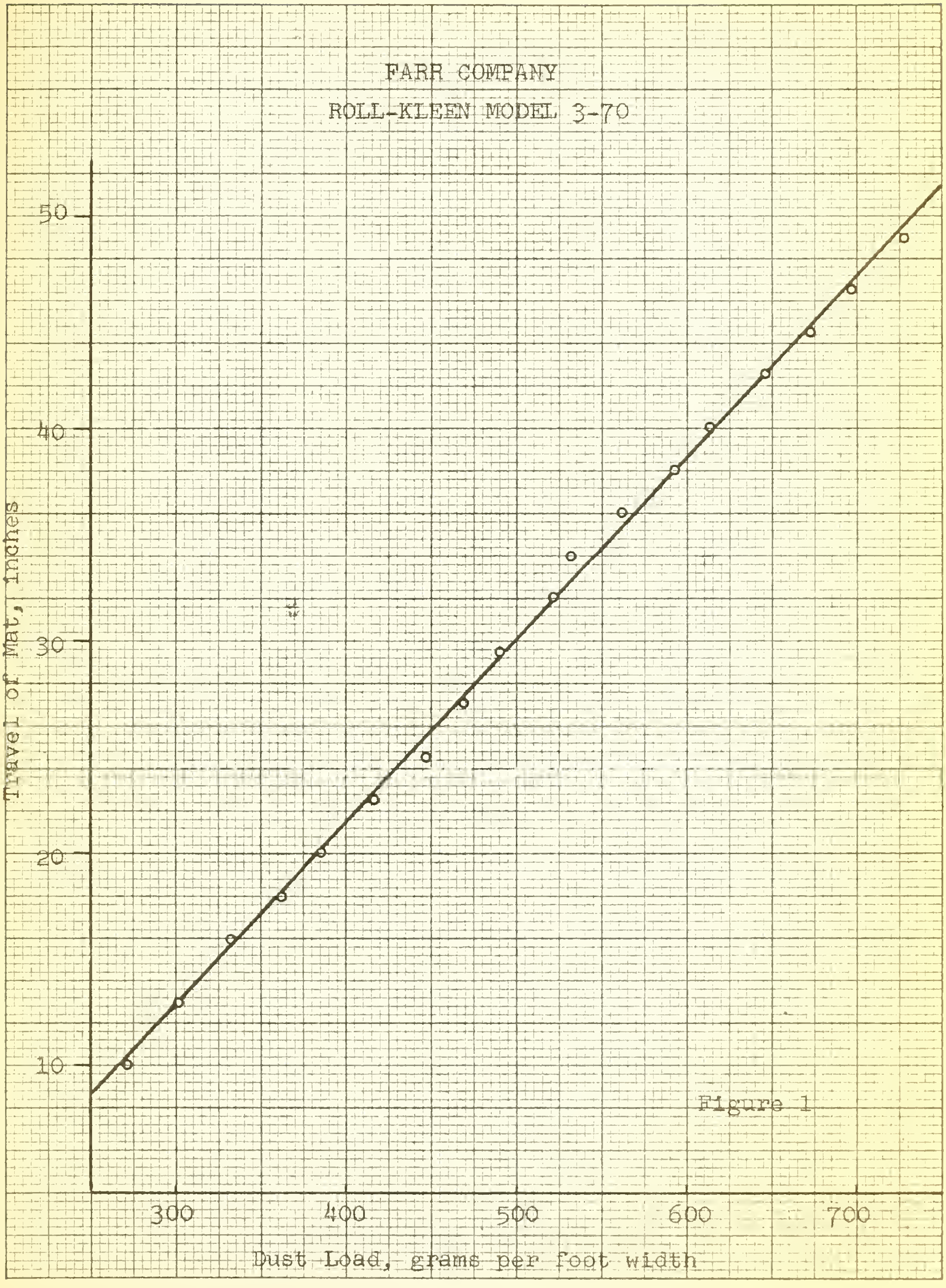
Average Arrestance*
    Clean Mat, Laboratory Air - 16%
    Cottrell Precipitate - 70%
    Steady State, Laboratory Air - 20%
    Cottrell Precipitate - 81%

Arrestance at Steady State with Cottrell Precipitate
    at 600 ft/min Face Velocity - 80%
    at 400 ft/min Face Velocity - 85%

Dust-Holding Capacity* - 140 g/ft width

* At rated face velocity of 500 ft/min.

MAT TRAVEL v/s DUST LOAD



U.S. DEPARTMENT OF COMMERCE
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THE NATIONAL BUREAU OF STANDARDS

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